Architecting an Approach to Knowledge Management

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This paper sets forth a method to develop an architectural approach to the design, development, creation, and implementation of knowledge management at a specific organization. The research is derived from qualitative analysis of published case studies, interviews, and a knowledge architecture developed and implemented by the author and her team at the National Aeronautics and Space Administration (NASA)'s Jet Propulsion Laboratory (JPL). The paper looks at critical success factors for successful deployments of knowledge management solutions: culture, architecture, infrastructure, and services.

The steps in developing a knowledge architecture are similar to those in developing an architecture for any complex information system, with the difference being that culture and services play a critical role in successful deployment of knowledge-based systems. The intent of this paper is to help companies design and implement successful knowledge management systems by starting out with an analysis and architectural approach to meeting their business needs.

> *Our dream today is not fundamentally about technology.*
>
> *Technology is a means to an end. Our dream is about*
>
> *communication—the most basic human strategy we use to raise*
>
> *our children, to educate, to heal, to empower, and to liberate. In its*
>
> *most basic form, communication is the transfer of information from*
>
> *one human being to another.*
>
> <div align="right">—Vice President Al Gore,</div>
>
> *1993[1]*

As we constantly strive to achieve more in our businesses, we sometimes lose sight of the essential reason we are in business—the need to communicate with others. Whether that communication occurs through conversations, publications, the use of a product or service, or electronically, the basic driver behind business is communicating—one person to another.

As we emerge from the information age into the new millennium, we move to an age where knowledge is required to do our tasks—knowledge about what we do, how to do it, and where to find the experts that will enable us to make better decisions. Such knowledge resides within organizations and within the minds of knowledge workers.

The aspects to managing that knowledge—that corporate memory—involve generating, organizing, developing, and distributing information to individual's so they can act upon it. The application of these actions is called knowledge management.

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[1] Targowski, A.S., *Global Information Infrastructure*, Idea Group Publishing, Harrisburg, PA, (p. I-1) 1996.
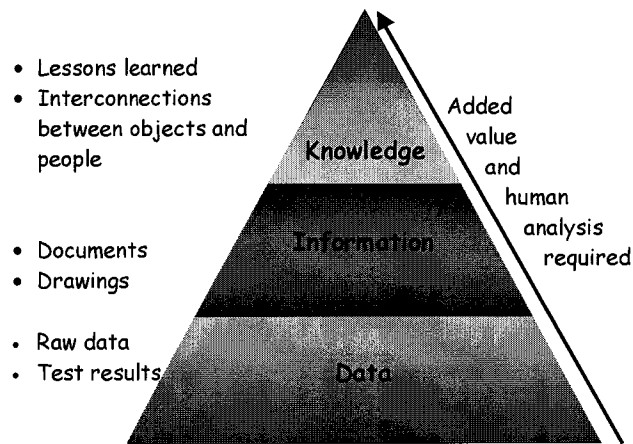
Introduction: What Is Knowledge Management?

How we define knowledge is essential to our understanding of how we manage it. Tom Davenport, one of the leaders in the field of knowledge management, believes:

> *Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories, but also in organization routines, processes, and norms.*[2]

Knowledge has often been described in relation to both data and information. One can envision knowledge at the top of a pyramid (Figure 1). The further up the pyramid one travels, the more human analysis is required to change the data to information and then to knowledge, and the more value is potentially added to the customer.

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[2] Davenport, T.H., and L. Prusak, *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, (p. 5), 1998.

- Lessons learned
- Interconnections between objects and people

- Documents
- Drawings

- Raw data
- Test results

Knowledge

Information

Data

Added value and human analysis required

FIGURE 1. THE KNOWLEDGE PYRAMID

Given this understanding of knowledge, we can then attempt to define the management of knowledge. CAP Ventures, a market research and consulting firm, finds "knowledge management encompasses management strategies, methods, and technologies for leveraging intellectual capital and know-how to achieve gains in human performance and competitiveness."[3] Others have focused on customer access to accurate, useful, and timely information. In essence, knowledge management is:

GETTING PEOPLE THE RIGHT INFORMATION AT THE RIGHT TIME SO THEY CAN ACT TO MEASURABLY IMPROVE THE PERFORMANCE OF THE ORGANIZATION AND ITS PARTNERS.

Since knowledge management has been used so frequently in today's marketplace, the term has been diluted to the point of unusability. By using the definition above, we can begin to focus on how knowledge management can be applied to leverage specific, concrete benefits for an organization. As with any strategy or theory, the only usefulness in a corporate setting is when it can be applied to add value to the customer.

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[3] DocuLabs presentation, Disney Studios, Studio City, California, September 17, 1998.

What are the Benefits of Knowledge Management?

The benefits of knowledge management can be hard to measure. Anecdotal information abounds in organizations that have implemented knowledge management initiatives as to how they were able to accomplish many of their objectives. Part of the true measure of knowledge management as a successful business tool will be to take some of these anecdotes and start to apply clear and meaningful metrics to KM tools and techniques. Some of the business objectives that are tackled by KM strategies include how to:

Find crucial information

Capture competitive advantages

Save money in patent and information management

Create a culture in which it was more important to think of the company's long-term needs rather than of the short-term task

- Improve efficiency by speeding up core processes or freeing up workers time for content production

- Avoid knowledge loss by compensating for the dilution or loss of experts

- Avoid costs and consequences of relearning lessons

- Stimulate knowledge growth and creation, for example, by improving collaborative environments and research support

- Recognize and reward knowledge reuse

However, not all organizations can invest the attention, time, and money needed to pull off knowledge management, and, truthfully, not all companies will receive a positive return on investment for their trouble if they do.

What knowledge management *can* clearly do for a company is provide faster, easier access to information already owned or maintained by that company. That information—more accurate, timely, and consistent than the information today—can lead to better decisions from the executive suite to the factory floor.

For example, a rigorous, standards-based approach to knowledge management allows a company to share knowledge along its value chain. A case study on AutoSTEP showed how, with the use of standards for product data exchange, knowledge could be passed along a value chain—decreasing design, manufacturing, and marketing costs.

Using STEP[4], a company can exchange data between different brands of manufacturing software that deal with the same data. The goal of AutoSTEP[5] is to improve the quality and timeliness of data exchange to minimize product-development cycle time. AutoSTEP focuses on both the STEP technology and product development business processes associated with product data exchange.[6] From the business view, AutoSTEP gives better integration of product and process design among automotive suppliers and customers. With AutoSTEP, the automotive industry gets accurate, timely, and cost-efficient exchange of product data and increases the coordination between development partners. Clearly, a great deal of savings of time and money has been attributed to knowledge management by simply eliminating non-value-added steps. By creating access to a computer-readable drawing or document, someone doesn't need to rekey that information when it is reused. Knowledge management also helps to capture intellectual capital for easy reuse and helps to preserve documented successes for future corporate capitalization.

The most fundamental change wrought by knowledge management is cultural— focusing people on meeting customer needs *together*, rather than hoarding knowledge *individually*.

Knowledge management helps to avoid continuing to do business ineffectively and inefficiently, and sets new processes in place to more easily enable people to share information.

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[4] STEP is the international ISO 10303 standard for neutral data formats.
[5] AutoSTEP is a product data exchange project for automotive supply chains.
[6] STEP web site: http://www.aiag.org/autostep/index.html

Purpose and Methodology

This paper sets forth a method to develop an architectural approach to the design, development, creation, and implementation of knowledge management at a specific organization. The research herein is derived from qualitative analysis of published case studies, as well as analysis of a knowledge architecture implementation at the National Aeronautics and Space Administration (NASA). The paper looked at critical success factors for successful deployments of knowledge management solutions.

The steps in developing a KM architecture are similar to those in developing an architecture for any complex information system (Figure 2). These steps are derived from the analysis of the case studies, implementation of the architecture at NASA, and published works by other authors, particularly Amrit Tiwana, *A Knowledge Management Toolkit*[7]. The intent of this paper is to help companies design and implement successful knowledge management systems by starting out with an analysis and architectural approach to meeting their business needs.

Benchmarking to Identify Critical Success Factors

In an earlier paper, the author explored case studies and current practices in knowledge management[8]. The business case most often cited for KM is to lower production costs through knowledge reuse, reduce cycle time and increase quality by sharing best practices, and to capture and leverage intellectual capital through capturing more organizational knowledge.

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[7] Tiwana, Amrit, *The Knowledge Management Toolkit: Practical Techniques for Building a Knowledge Management System*, Prentice Hall, NJ, 2000.

The analysis showed that certain cultural factors are critical to success if KM is to succeed (Figure 2)

- ☐ Recognize and reward people for sharing knowledge

- ☐ Encourage and support communities of practice

- ☐ Strike a balance between long-term corporate needs (capturing knowledge) with short-term local needs (completing a task quickly)

The potential showstoppers relate to cultural issues and perceptions. If people are unwilling to share their own knowledge or to use information from others, knowledge management *will* fail. Conventional processes tied to older and slower ways of doing business are entrenched in most organizations. For example, while product development has been forced to radically evolve to frequent deliveries to market, business processes within an organization have not been held to the same rigor. When a product manager's needs intersect with a business process, friction can occur as the two often have vastly different time frames.

Faster paced, collaborative work environments apply stress to conventional organizational structures. Most people want to share what they know, but incentive structures neither reward them for doing so, nor allow them the time to share. Organizations must adapt and reshape themselves to the new environments for KM to succeed (Figure 3).

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[8] Holm, J. and J. Byun, *Knowledge Management: Bringing Power to Your Company*, presentation at Claremont Graduate University, Claremont, California, November 24, 1998.

Deliver training
Mainstream services
Create strategic tools
Form partnerships

Culture

Balance corporate and local goals
Facilitate communities of practice
Create rewards and recognition
Recognize ownership
Enable sharing and reuse

Supporting Services

Knowledge Management

Knowledge Architecture

Specific access methods
Create building blocks
Adopt standards
Sustain service bases

IT Infrastructure

Capture content
Provide context
Require interoperability
Maintain directories
Develop and gather repositories
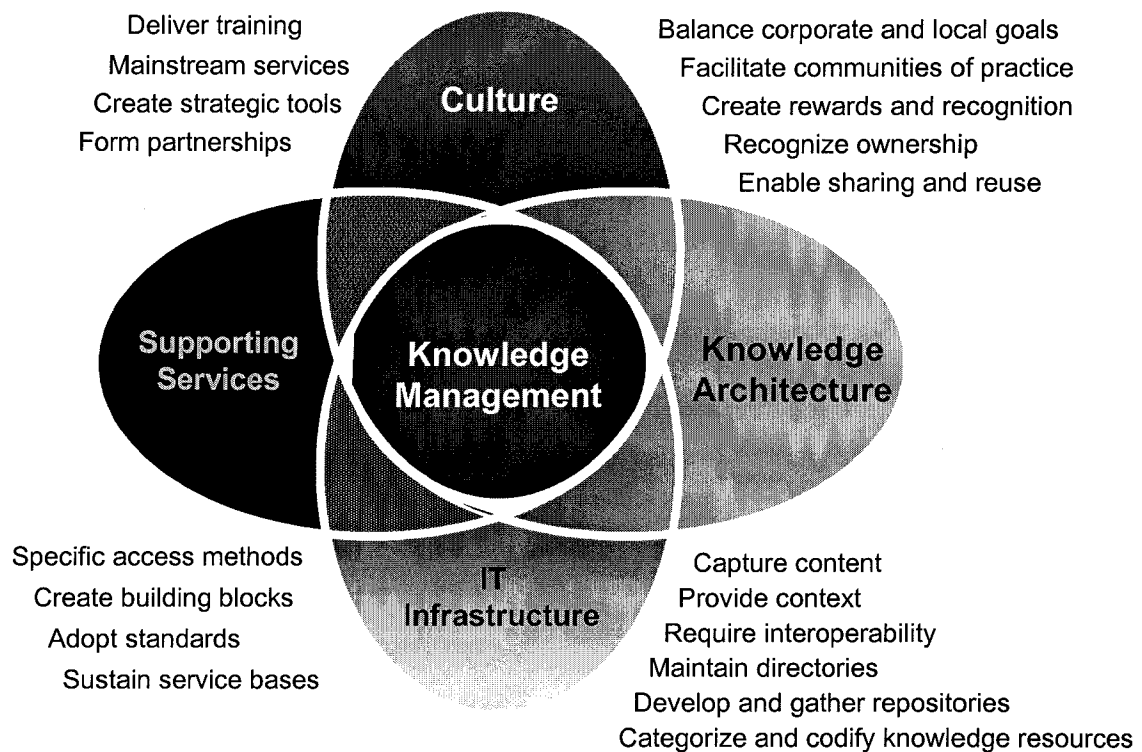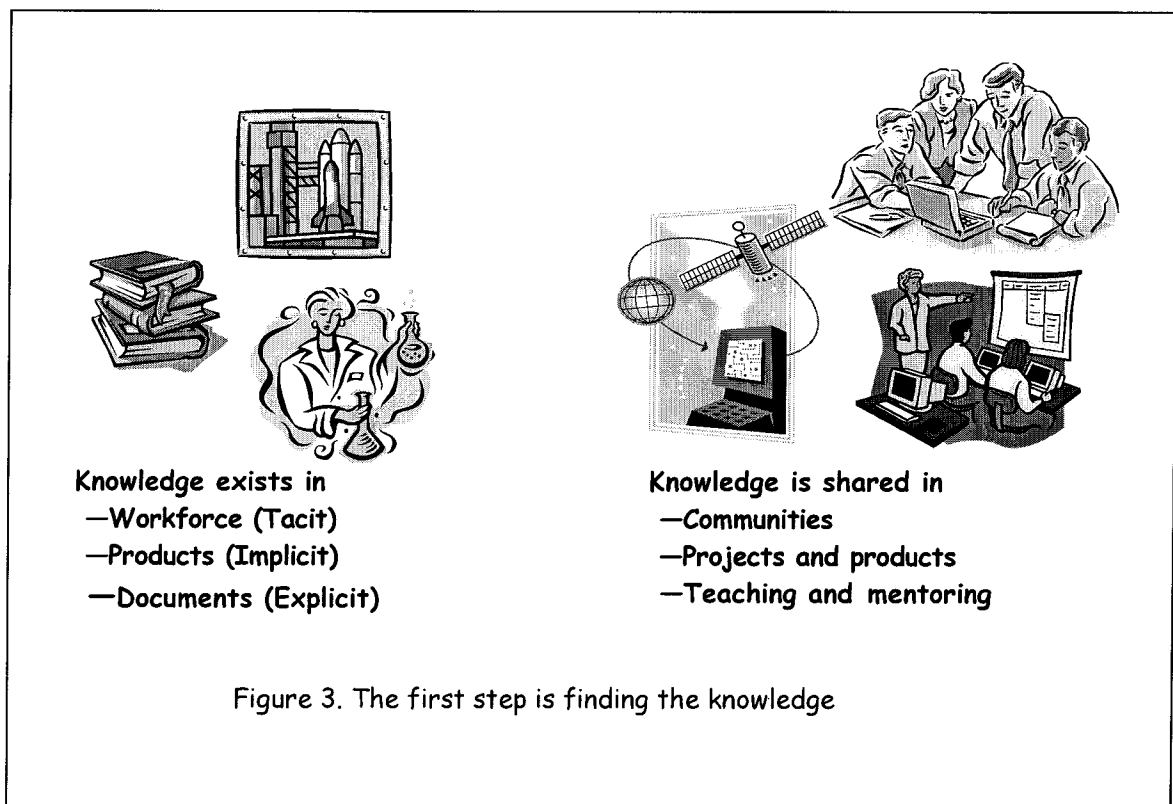Categorize and codify knowledge resources

Figure 2. Critical success factors for knowledge management.

Additionally, many organizations found that implementing KM in phases, carefully selecting technologies, incorporating security early in the lifecycle, and adopting standards contributed to the development of successful systems.

☐ Implementations of KM systems are commonly aggregates of existing systems, or they represent very large systems that are much too complex to implement monolithically and on a large scale. Phased implementation, using rapid prototyping or starting with a single community, is one approach that has met with success. Most initial implementations of KM systems have focused on collecting and indexing corporate knowledge.

☐ Information security issues are integral to KM and must be woven into KM processes and architectures. Layered security is a common approach to scaling security in an appropriate manner and embedding security into the tools. The structure of KM systems and processes needs to reflect that there are proprietary rights between corporate partners on a project and that federal regulations oversee some of the dealings with international partners.

☐ Data format issues can haunt the initial implementations of KM, and thus early adoption of information architecture and data standards (such as core metadata and development of a data dictionary) have an early return on investment.

Knowledge exists in
—Workforce (Tacit)
—Products (Implicit)
—Documents (Explicit)

Knowledge is shared in
—Communities
—Projects and products
—Teaching and mentoring

Figure 3. The first step is finding the knowledge

Supporting Services

Second to overlooking cultural issues, KM implementations most frequently fail because

organizations do not create full services behind their KM products. Systems are built, but

left to wither without adequate maintenance or support personnel to help the customers

use the systems. A full service base acknowledges that the system needs hardware,

software, and people to create a usable business tool and to provide ongoing service and

training to people using the system to get their jobs done.

Knowledge Architecture

The architectural approach to knowledge management has been used at several

companies. In these cases, the intent is to gather requirements from the customers (which

may be internal, external, or both) and develop a suite of systems and/or services that will

deliver the desired functionality to the customer. This approach often catches issues that

are overlooked or ignored by more straightforward approach that focus strictly on system

implementation or purchase of a vendor suite. These areas fall into two main categories:

interoperability and information context.

Developers tend to optimize their system at the level at which they are focused—

generally to a task or business unit. Unfortunately, this often causes large problems at the

enterprise level when cross-functional work teams (or managers) are trying to find

information across the enterprise. As a result, architectures address specific issues at the

enterprise level like directories, metadata, and object libraries.

In the other area of context, KM solutions often ignore the fact that access to more

information does not innately give people the ability to make better decisions. The

information that people have access to needs to be accurate and timely. Someone needs to

take responsibility for the content of the information, as well as keeping or putting that content in context.

As companies are developing their approaches for knowledge management, some of them are creating cornerstones—those tenets that should not be changed as the approach or architecture evolves. Examples of these cornerstones are:

Keep it simple—build only what is necessary to complete a capability
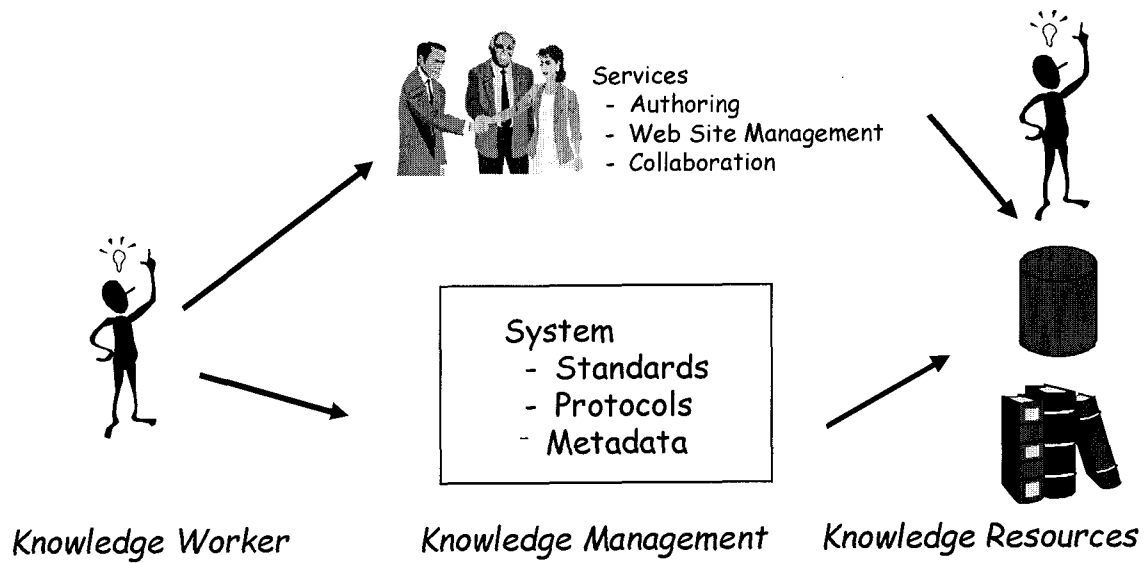
Standardize only what's necessary to hold things together—keep mandated requirements to a minimum

Federation before unification—combine or upgrade existing capabilities where necessary to meet KM requirements and to provide services to the enterprise

Provide institutional support for institutional services—support interoperability, development of professional service bases, migration tools to standard systems, application support and training, and application refreshment

Creating the Knowledge Architecture

In companies that are recognized for doing a good job in knowledge management, they tend to recognize three main areas: processes, systems, and data. The goal of KM is, of course, to unite someone with a good idea to the information or people he or she needs to develop that good idea into a deliverable to support the organization's goals (Figure 4).

Services
- Authoring
- Web Site Management
- Collaboration

System
- Standards
- Protocols
- Metadata

Knowledge Worker　　　　Knowledge Management　　　Knowledge Resources

FIGURE 4. KNOWLEDGE ARCHITECTURE KEY ELEMENTS

KM processes exist to provide enabling services for what people actually do. The KM-centric view of those processes focus on how to capture, develop, organize, and distribute knowledge (Figure 5).
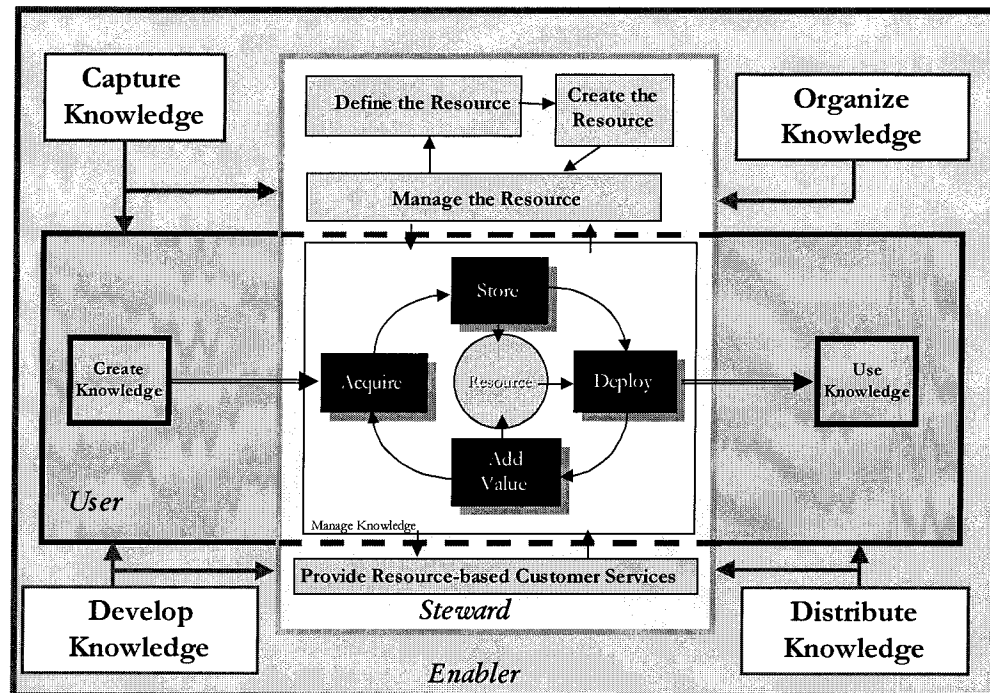
FIGURE 5. A PROCESS VIEW OF KNOWLEDGE MANAGEMENT (COURTESY OF LYNN COOPER).

Capturing knowledge involves helping people articulate knowledge that can be easily shared and reused. They need to have services (people or software) that supporting their teams or experts in moving tacit knowledge to explicit knowledge. These services have to facilitate groups working collaboratively, and coach teams in sharing knowledge both synchronously and asynchronously. Capturing knowledge also means helping task-specific stewards define knowledge resources to meet their customers' needs within the organizational standards and goals, and to identify institutionally needed knowledge resources.

The organization knowledge process works on sorting information so that people can easily share it, find it, and use it once it's found. This process looks at structuring

information in standardized ways for use by others, setting standards for information storage and retrieval, and enabling knowledge-sharing systems and tools.

The develop knowledge process helps to refine knowledge so that it can be easily reused by others (such as others on a project, a customer, or future projects). This includes (1) selecting which knowledge will be most useful based on the question asked or the need defined; (2) filtering contributions to the knowledge base so that the most critical lessons learned are marked for easy retrieval, including filtering provided by domain experts; and (3) enabling documents and drawings to be shared across systems by providing conversion tools.

Finally, the distribute knowledge process helps people get access to knowledge, encourages people to use and reuse knowledge, trains people in how to use the knowledge management tools, and provides help for people searching for information.

KM System Architecture

The goals of the system architecture are to provide access to knowledge *AND* to provide security and integrity of that knowledge. The two main components of that architecture include the information system architecture and the data architecture.

The information system should address:

- User interface (client application and presentation)

- Knowledge management functions (search, browse, retrieve, index, add value, update, archive, filter, catalog, analyze, validate, and associate)

- Application infrastructure services (made up of reusable components and provide connectivity between user interface and underlying knowledge resources such as human resources, document management, web site management, and business systems)

- Knowledge resources (internal, application-specific security, data warehouses, databases, libraries, people, web sites, directories, and publications)

- Infrastructure services (security, networks, data hosting, messaging, and file services)

Data Architecture

The data architecture needs to address the issues of how data will be found today and tomorrow within the organization. Common questions that organizations have difficulty answering are: how will the data be maintained?; What standards will ensure efficient data reuse?; and What are our current knowledge resources and what should they be in the future?.

Some of these questions are more involved than they appear. For example, just describing an organization to the level of detail needed is hard. Most organizations exist in a virtual space, with members living around the globe, and often team members are employees of multiple companies. Metadata is more than just name and title, but should also include identifier, date, version, description, and key words.

- Data sources and owners

- Standard data formats (such as TCP/IP, XML, or CORBA)

- Interchange data formats

- Data access

- Metadata standards

- Data replication and transfer (residing on many servers across multiple companies, maintenance, seeking the gold standard, and referenced through standard access protocols)

- Data dictionary (standard objects, values, and attributes across the organization, including industry standard items such as schemas)

Recommended Near-Term Services

Each organization needs to choose the services that they will implement first. Several companies have failed by choosing to do too much, too quickly. It is critical to remember that culture is the key barrier to successful knowledge management implementation. If an organization moves too quickly in creating new technological solutions, the culture will not be ready to accept them.

Therefore, the choice and number of initial services offered by knowledge management should be made carefully. Some of the criteria that have been used for this selection include:

- Availability of personnel

- Funding

- Internal KM customer needs

- External customer needs

- Existing duplication of services

- Chance of success (complexity, technological readiness)

Conclusion

Overall, it is important to approach knowledge management as an architectural task:

- **Process**: Centered around the organization's core business processes, knowledge management processes facilitate what **people** need to do to acquire, reuse, update, store, and deploy information (see Figure 6).

- **System**: Develop requirements from producers and consumers of knowledge

- **Data**: Standardize the metadata, formats, and management of data across the enterprise to ensure that the bottom of your knowledge pyramid is stable.
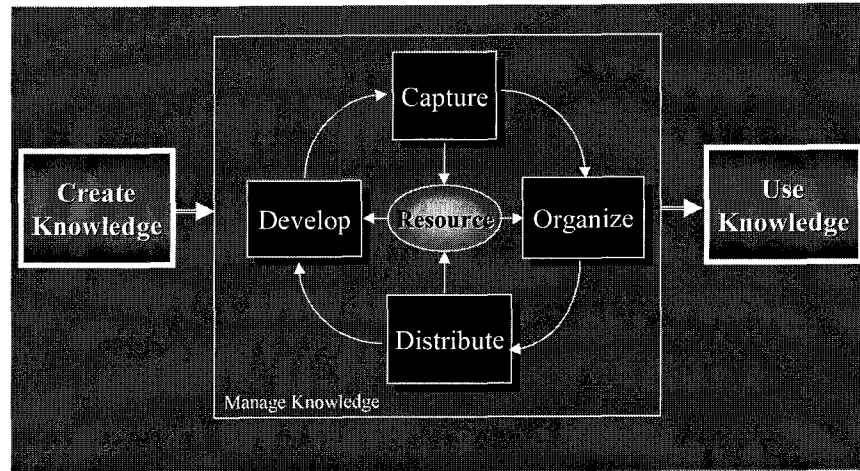
FIGURE 6. THE BASIC KM PROCESS MAP

Once the architecture is complete, the roadmap for how an organization will get from today to tomorrow is critical, as well as a phased implementation strategy to take advantage of maturing technologies.

In developing a knowledge architecture, it is essential to gather user requirements, benchmark best internal and external practices, and test those against users' expectations. Since a knowledge management strategy can be large, costly, and risky, a phased implementation is crucial—one that has some early successes that can be easily achieved to prove the concept of supportive KM systems and services to both management and the customers.

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